Edward T Lu, mission specialist, photographed by his spacewalking colleague, cosmonaut Yuri I Malenchenko, during the 6-hour space walk the two performed around the International Space Station (NASA).

The scientific case for human spaceflight

Ian Crawford and **Sarah Dunkin** report on discussion at the National Astronomy Meeting in Cambridge in April, which marked two key dates in the history of human spaceflight, as well as looking forward to the challenges that will demand human intelligence and ingenuity in space in future.

Forty years ago, on 12 April 1961, Yuri Gagarin initiated the era of human spaceflight with his single, 108 minute orbit of the Earth on board Vostok 1. Coincidentally, 12 April 2001 was also the 20th anniversary of the launch of the first US Space Shuttle, Columbia. In order to mark these key anniversaries in the history of human space exploration and to explore the scientific issues surrounding human spaceflight, a one-day meeting was held on 5 April 2001, as part of this year's National Astronomy Meeting in Cambridge.

Kevin Fong (University College Hospital) began the day with a discussion of life sciences research to be conducted on the International Space Station (ISS). He noted that the impact of the space environment upon living organisms is profound, with effects ranging from alterations in subcellular processes to changes in the structure and function of whole organ systems. In the next 15 years the ISS will serve as a dedicated life and physical sciences platform for the investigation of these phenomena. The experiments will include efforts in fundamental biology, human physiology, behavioural science and space biomedical research. As well as providing new insights, novel therapeutic interventions and improved biotechnology for terrestrial applications, this research on human physiology is an essential prerequisite for sending astronauts on long-duration space missions (such as to Mars). Fong concluded with a heartfelt plea for greater UK involvement in ESA's human spaceflight programme.

Olivier Minster (ESA–ESTEC) then described some of the basic and applied physical research to be conducted on the ISS. ESA has set up a research strategy for future activities in the field of life and physical sciences research in the space environment, encompassing both basic and applied research. Minster stressed that there is significant interest from the (non-space) industrial sector in ISS microgravity research to be conducted on bulk material properties, crystal growth and combustion.

As part of the RAS Ordinary Meeting, **Arvind Parmar** (ESA–ESTEC) then described three high-energy astronomy missions that ESA is currently studying with a view to exploiting the ISS. These are Lobster, an all-sky imaging X-ray monitor; the Extreme Universe Space Observatory (EUSO), which will study the highest energy cosmic rays by using the Earth's atmosphere as a giant detector; and XEUS – the X-ray Evolving Universe Spectroscopy Mission which is a potential successor to XMM-Newton. The first two missions will be attached to the external platforms on the Columbus module, while XEUS will visit the ISS to attach additional X-ray mirrors to enlarge the original 4.5 m diameter mirrors to the 10 m diameter required to observe redshifted iron lines from massive black holes in the early universe.

Beyond the ISS

After lunch, **Paul Spudis** (Lunar and Planetary Institute, Houston) made the strongest possible case for renewed human exploration of the Moon. He argued that we can learn about the geological processes that have shaped all of the terrestrial planets by studying the well-preserved record of the Moon, and also that the Moon is a superb platform for astronomical observation. Both of these objectives will require the guiding presence of human intelligence, flexibility, decision-making and adaptation: no-one has yet built a robot that duplicates or comes close to these human qualities. Thus, beyond the sheer adventure of human spaceflight, people will be needed to carry out the complex, second-generation scientific exploration of the planets.

Alex Ellery (Queen Mary and Westfield, London) then gave a robotics perspective on human spaceflight. While there is vigorous debate over whether human or robotic space exploration is preferable, Ellery argued persuasively that these are not mutually exclusive – rather they afford an efficient division of labour. This collaboration is driven by limitations on autonomous robotics technology, and wholesale replacement of humans by machines for space exploration will not be possible for the foreseeable future if scientific returns are to be optimized.

The next speaker was **Julian Hiscox** (University of Reading) who gave an exobiological perspective on the human exploration of Mars. He pointed to evidence that the climates of ancient Mars and ancient Earth may have been very similar; if an origin-of-life event occurred on the Earth, there is no reason to assume that it did not also occur on Mars. Traces of an ancient Martian life might still be present today. However, Hiscox pointed out that so far we have only scraped and scratched at the surface of Mars and he argued that if we are to unlock its secrets we will need to send human explorers armed with drills and rock hammers.

Stepping out: the International Space Station in September 2000, taken from the shuttle Atlantis (NASA).

Nick Cross (University of St Andrews) continued this theme, reminding us that Mars is a fascinating planet with amazing surface features and a rich geological history. He discussed some of the scientific questions that we have about Mars, and its relation to other bodies in the solar system, before talking about why human exploration would be beneficial to the scientific work. He then went on to discuss why Mars would be a more suitable target than other planetary bodies and how exploration of Mars will lead to easier exploration of the rest of the solar system.

Robots or people?

The penultimate talk was given by **Andrew Coates** (Mullard Space Science Laboratory), who presented an opposing view to those who advocate the use of humans in the scientific exploration of space. While acknowledging that human spaceflight represents a heady mix of bravery and drama that can be inspirational to nations and to humankind, he was concerned by its high cost. He pointed out that, due to the current high launch costs, only a handful of people have ventured beyond low Earth orbit and walked on the Moon, while cheaper robotic probes have visited all the planets except Pluto. Public interest in the historic Eros landing eclipsed a simultaneous spacewalk at the fledgling ISS, and the Mars Pathfinder landing generated hundreds of millions of website hits in a few days. Given that hundreds of Mars missions could be flown for the still-escalating cost of the ISS, the unsuitability of human bodies for deep space exploration, and advances in virtual reality techniques, Coates doubted that human exploration has a place in a realistic, useful and inspirational space programme.

The final talk was given by **Ian Crawford** (University College London) on "the scientific case for a human spaceflight infrastructure". He argued that science stands to benefit greatly from the *infrastructure* developed to support a human space programme. By this is meant all those facilities and capabilities (e.g. launch vehicles, astronauts, space stations, lunar and planetary bases) that purely scientific budgets could never afford to develop, but that nevertheless act to facilitate scientific research that would not otherwise take place. For example, the human presence on the Moon during the Apollo Project resulted in the acquisition of scientific data that would not have been obtained otherwise, and he argued that the same will hold true for future human missions to both the Moon and Mars. He speculated that, in the more distant future, an important application of a human spaceflight infrastructure may be the construction of interstellar space probes for the exploration of the planets recently discovered around other nearby stars.

Overall the meeting was a great success, attracting a lot of press coverage, with articles in at least three daily newspapers and several radio and television appearances by participants. We have come a long way since Gagarin made that first historic journey into space and there appeared to be a broad consensus at the meeting that scientific benefits will result from a human presence in space. For those interested, the full proceedings of the meeting will be published in a special issue of *Earth, Moon and Planets* in due course. ●

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